RCA linear integrated circuits

Multipurpose Wide-Band Power Amplifiers

Monolithic Silicon

CA3020
CA3020A

File No. 339

The RCA-CA3020 and CA3020A are Integrated-Circuit, Multistage, Multipurpose, Wide-Band Power Amplifiers on a single monolithic silicon chip. They employ a highly versatile and stable direct-coupled circuit configuration featuring wide frequency range, high voltage and power gain, and high power output. These features plus inherent stability over a wide temperature range make the CA3020 and CA3020A extremely useful for a wide variety of applications in military, industrial, and commercial equipment.

The CA3020 and CA3020A are particularly suited for service as Class B power amplifiers. The CA3020A can provide a maximum power output of 1 watt from a 12-volt DC supply with a typical power gain of 75 dB. The CA3020 provides 0.5 watt power output from a 9-volt supply with the same power gain.

These types are supplied in hermetically sealed, TO-5 style 12-lead packages.

SCHEMATIC DIAGRAM FOR CA3020 AND CA3020A

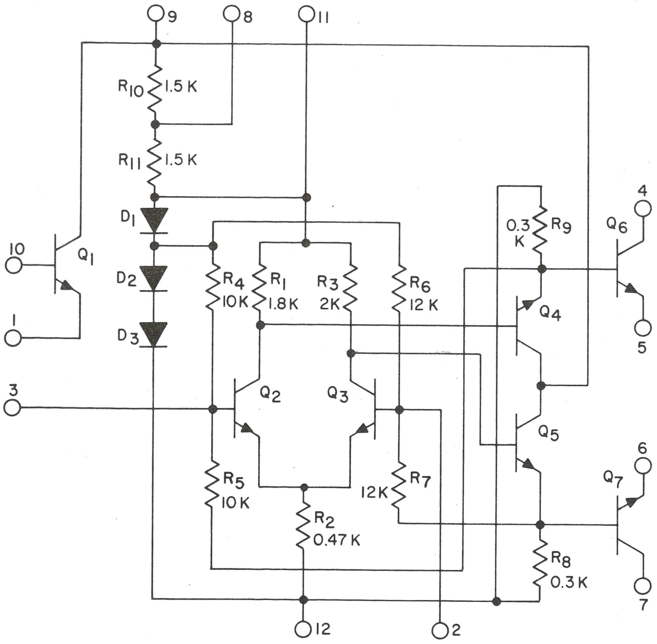


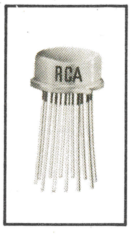
Fig.1

The resistance values included on the schematic diagram have been supplied as a convenience to assist Equipment Manufacturers in optimizing the selection of "outboard" components of equipment designs. The values shown may vary as much as ± 30%.

RCA reserves the right to make any changes in the Resistance Values provided such changes do not adversely affect the published performance characteristics of the device.

MULTIPURPOSE WIDE-BAND POWER AMPLIFIERS

For Military, Industrial, and Commercial Equipment at Frequencies up to 8 MHz



12-Lead TO-5

FEATURES

- High power output - class B amplifier --
  CA3020 .... 0.5 watt typ. at V_{CC} = + 9V
  CA3020A ... 1.0 watt typ. at V_{CC} = + 12V
- Wide frequency range --
  Up to 8 MHZ with resistive loads
- High power gain .... 75db typ.
- Single power supply for class B operation with transformer --
  CA3020 .... 3 to 9V
  CA3020A .... 3 to 12V
- Built-in temperature-tracking voltage regulator provides stable operation over -55°C to +125°C temperature range

APPLICATIONS

- AF power amplifiers for portable and fixed sound and communications systems
- Servo-control amplifiers
- Wide-band linear mixers
- Video power amplifiers
- Transmission-line driver amplifiers (balanced and unbalanced)
- Fan-in and fan-out amplifiers for computer logic circuits
- Lamp-control amplifiers
- Motor-control amplifiers
- Power multivibrator
- Power switches
- Companion Application Note, ICAN 5766 "Application of CA3020 and CA3020A Integrated Circuit Multipurpose Wide-Band Power Amplifiers."

RCA Electronic Components

Supersedes File No.238 dated 9-67
Printed in U.S.A. | 6-68

ABSOLUTE-MAXIMUM RATINGS:

DISSIPATION: WITHOUT HEAT SINK		WITH HEAT SINK	
At $T_A = 25^oC$	1 W	At $T_C = 25^oC$	2 W
Above $T_A = 25^oC$	derate linearly 6.7 mW/^oC	At $T_C = 25^oC$ to $T_C = 55^oC$	2 W
		Above $T_C = 55^oC$	derate linearly 16.7 mW/^oC

TEMPERATURE RANGE:

Operating	-55°C to +125°C
Storage	-65°C to +200°C

MAXIMUM VOLTAGE RATINGS at $T_A = 25^oC$

The following chart gives the range of voltages which can be applied to the terminals listed vertically with respect to the terminals listed horizontally. For example, the voltage range of the vertical terminal 1 with respect to terminal 12 is 0 to +10 volts.

TERM-INAL No.	1	2	3	4	5	6	7	8	9	10	11	12
1		*	*	*	*	*	*	*	▲ 0 -10/-12	+3 Note 1	*	+10 0
2			*	*	*	*	*	*	*	*	*	+2 -2
3				*	*	*	*	*	*	*	*	+2 -2
4					▲ +18/+25 0	*	*	*	*	*	*	▲ +18/+25 0
5						*	*	*	*	*	*	+3 Note 2
6							▲ 0 -18/-25	*	*	*	*	+3 Note 2
7								*	*	*	*	▲ +18/+25 0
8									Note 3	*	*	Note 3 0
9										+10 0	Note 1 0	+10/+12 0
10											*	+10 0
11												*
12												REF. SUB-STRATE

MAXIMUM CURRENT RATINGS

TERM-INAL No.	I_{IN} mA	I_{OUT} mA
1	-	20
2	-	-
3	-	-
4	300	-
5	-	300
6	-	300
7	300	-
8	-	-
9	20	-
10	1	-
11	20	-
12	-	-

Note 1: This voltage is established by the maximum current rating.

Note 2: The emitters of Q_6 and Q_7 may be returned to a negative voltage supply through emitter resistors. Current into terminal No.9 should not be exceeded and the total device dissipation should not be exceeded.

Note 3: Terminal No.8 may be connected to terminals Nos.9, 11, or 12.

* Voltages are not normally applied between these terminals. Voltages appearing between these terminals will be safe if the specified limits between all other terminals are not exceeded.

▲ Higher value is for CA3020A.

ELECTRICAL CHARACTERISTICS AT $T_A = 25^oC$

CHARACTERISTICS	SYMBOLS	TEST CONDITIONS CIRCUIT AND PROCEDURE	TEST CONDITIONS DC SUPPLY VOLTAGE		LIMITS CA3020			LIMITS CA3020A			UNITS
		FIG.	V_{CC1}	V_{CC2}	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Collector-to-Emitter Breakdown Voltage, Q_6 & Q_7 at 10 mA	$V_{(BR)CEO}$	-	-	-	18	-	-	25	-	-	V
Collector-to-Emitter Breakdown Voltage, Q_1 at 0.1 mA	$V_{(BR)CEO}$	-	-	-	10	-	-	10	-	-	V
Idle Currents, Q_6 & Q_7	I_4 IDLE I_7 IDLE	8	9.0	2.0	-	5.5	-	-	5.5	-	mA
Peak Output Currents, Q_6 & Q_7	I_4PK I_7PK	8	9.0	2.0	140	-	-	180	-	-	mA
Cutoff Currents, Q_6 & Q_7	I_4 CUTOFF I_7 CUTOFF	8	9.0	2.0	-	-	1.0	-	-	1.0	mA
Differetial Amplifier Current Drain	I_{CC1}	8	9.0	9.0	6.3	9.4	12.5	6.3	9.4	12.5	mA
Total Current Drain	I_{CC1} + I_{CC2}	8	9.0	9.0	8.0	21.5	35.0	14.0	21.5	30.0	mA
Differential Amplifier Input Terminal Voltages	V_2 V_3	8	9.0	2.0	-	1.11	-	-	1.11	-	V
Regulator Terminal Voltage	V_{11}	8	9.0	2.0	-	2.35	-	-	2.35	-	V
Q, Cutoff (Leakage) Currents: Collector-to-Emitter	I_{CEO}	-	10.0	-	-	-	100	-	-	100	µA
Emitter-to-Base	I_{EBO}		3.0	-	-	-	0.1	-	-	0.1	
Collector-to-Base	I_{CBO}		3.0	-	-	-	0.1	-	-	0.1	
Forward Current Transfer Ratio, Q_1 at 3 mA	h_{FE1}	-	6.0	-	30	75	-	30	75	-	
Bandwidth at -3 dB Point	BW	9	6.0	6.0	-	8	-	-	8	-	MHz
Maximum Power Output	$P_{O(MAX)}$	10	6.0	6.0	200	300[a]	-	200	300[a]	-	mW
			9.0	9.0	400	550[a]	-	400	550[a]	-	
			9.0	12.0	-	-	-	800	1000[b]	-	
Sensitivity for P_{OUT} = 400 mW	e_{IN}	10	9.0	9.0	-	35[a]	55	-	-	-	mV
Sensitivity for P_{OUT} = 800 mW	e_{IN}	10	9.0	12.0	-	-	-	-	50[b]	100	mV
Input Resistance---- Terminal 3 to Ground	R_{IN3}	11	6.0	6.0	-	1000	-	-	1000	-	Ω
Junction-to-Case Thermal Resistance	θ_{J-C}	-	-	-	-	-	60	-	-	60	°C/W

[a] $R_{CC} = 130\Omega$

[b] $R_{CC} = 200\Omega$

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TYPICAL AUDIO AMPLIFIER CIRCUIT UTILIZING THE CA3020 OR CA3020A AS AN AUDIO PREAMPLIFIER AND CLASS B POWER AMPLIFIER

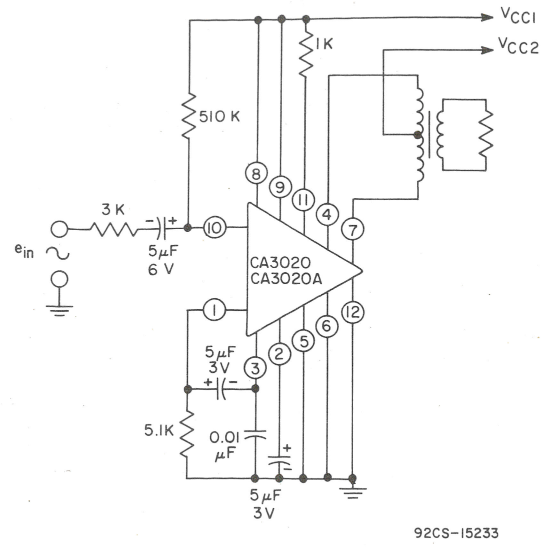


Fig.2

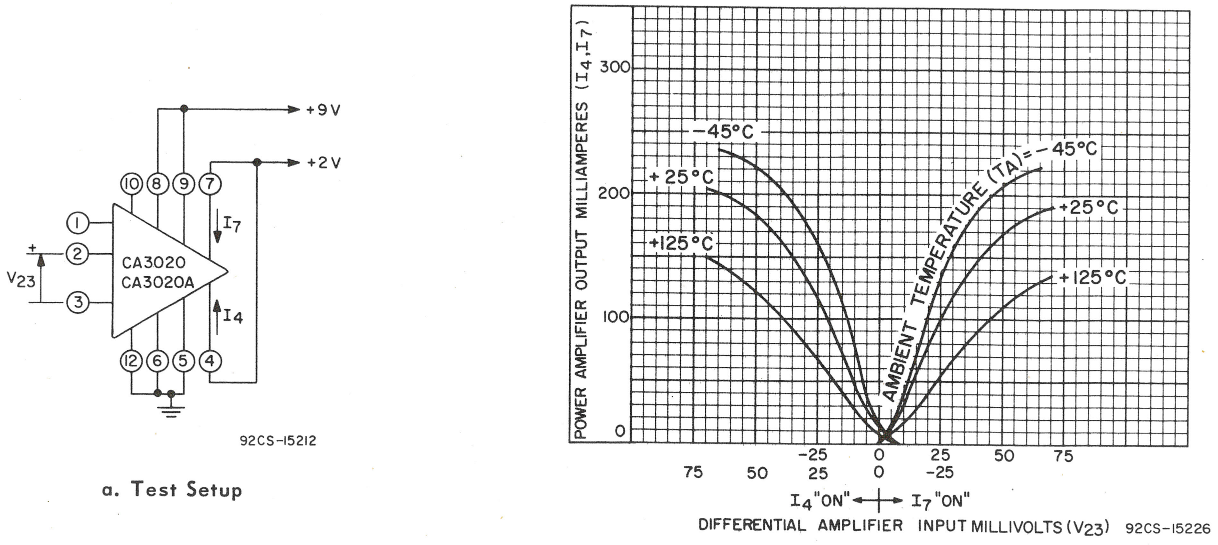
TYPICAL PERFORMANCE DATA*

An External Radiator is Recommended for High Ambient Temperature Operation

CHARACTERISTICS		SYMBOLS	CA3020	CA3020A	UNITS
Power Supply Voltage		V_{CC_1}	9.0	9.0	V
		V_{CC_2}	9.0	12.0	
Zero Signal Current	Diff. Ampl.	I_{CC_1}	15	15	mA
	Output Ampl.	I_{CC_2}	24	24	
Maximum Signal Current	Diff. Ampl.	I_{CC_1}	16	16.6	mA
	Output Ampl.	I_{CC_2}	125	140	
Maximum Power Output at THD = 10%		Po	550	1000	mW
Sensitivity		e_{IN}	35	45	mV
Power Gain		G_P	75	75	dB
Input Resistance		R_{IN}	55	55	kΩ
Efficiency		η	45	55	%
Signal-to-Noise Ratio		S/N	70	66	dB
THD at 150 mW level			3.1	3.3	%
Test Signal Frequency from 600Ω Generator			1000	1000	Hz
Equivalent Collector-to-Collector Load Resistance		R_{CC}	130	200	Ω

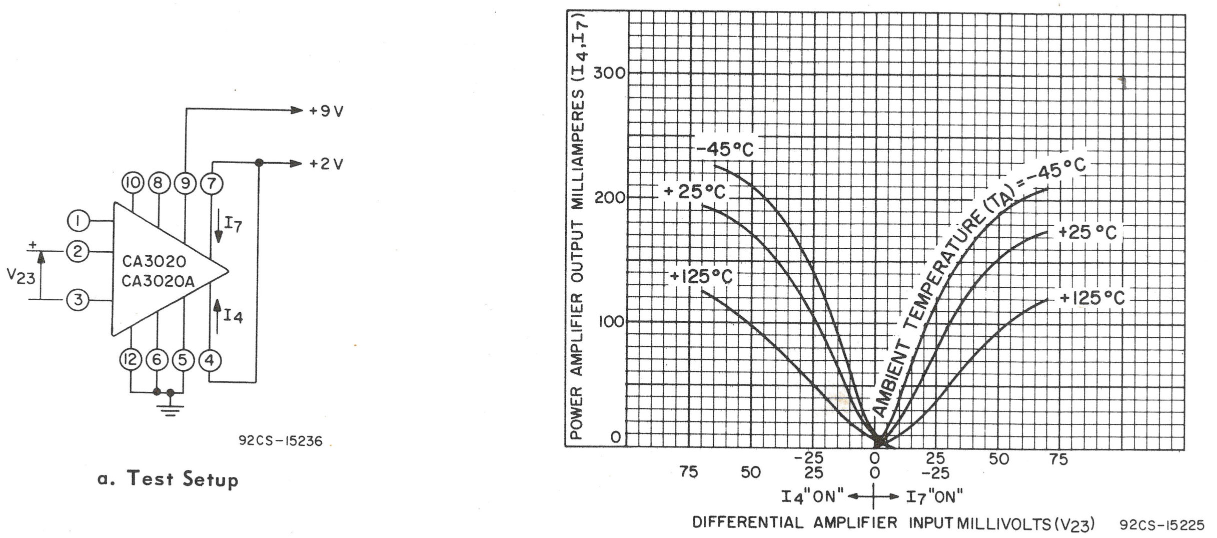
* Refer to Figs.8 through 12 for Measurement and Symbol Information.

TYPICAL TRANSFER CHARACTERISTICS



a. Test Setup

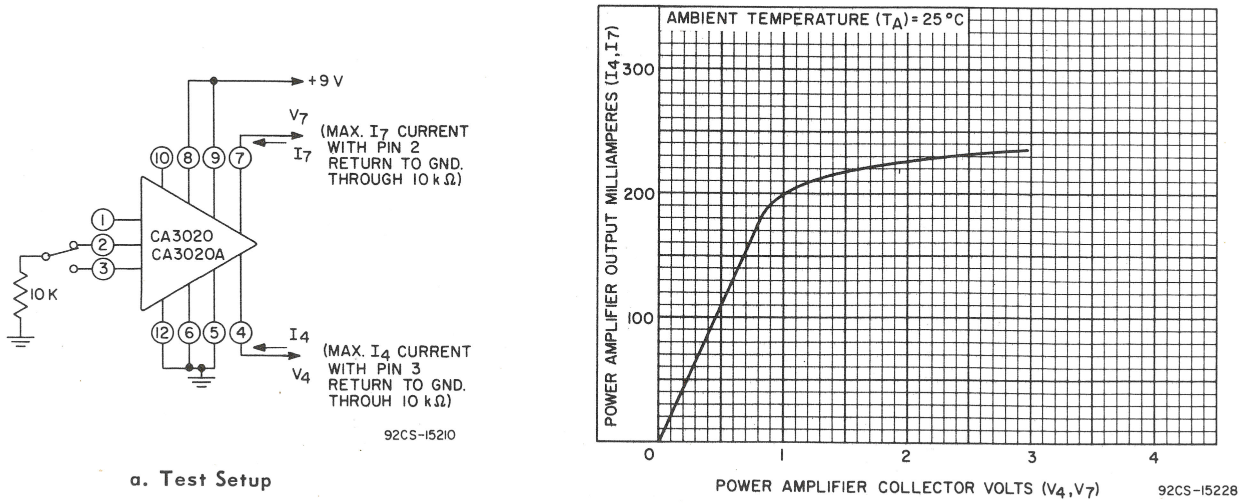
Fig.3 b. Characteristics with R_{10} shorted out



a. Test Setup

Fig.4 b. Characteristics with R_{10} in circuit

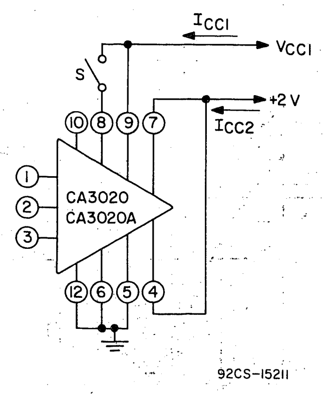
"MINIMUM DRIVE" TYPICAL CURRENT-VOLTAGE SATURATION CURVE



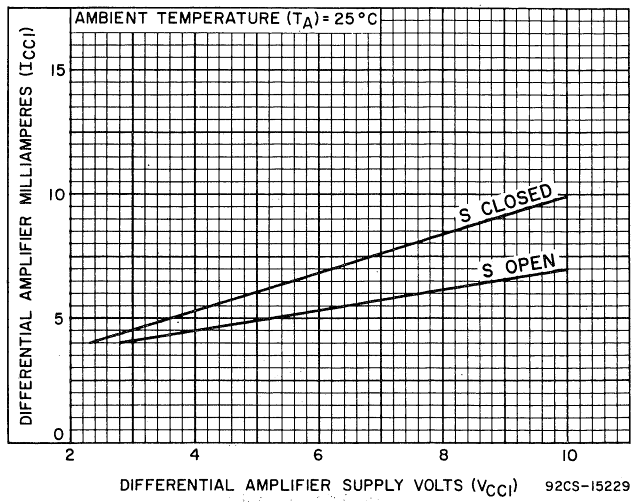
a. Test Setup

Fig.5 b. Characteristic

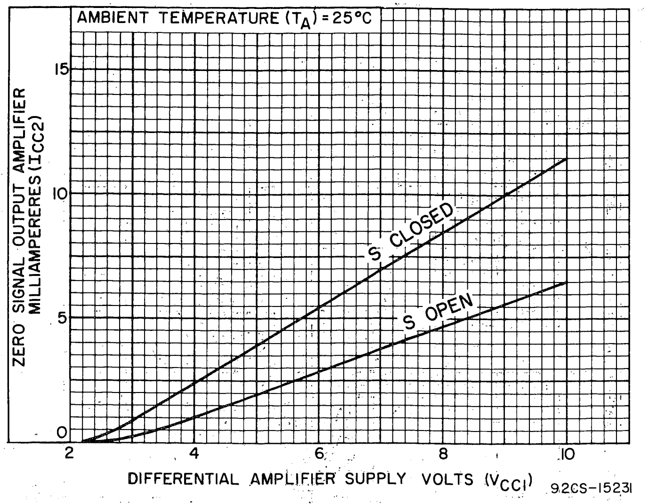
ZERO SIGNAL AMPLIFIER CURRENT vs DIFFERENTIAL AMPLIFIER SUPPLY VOLTAGE



a. Test Setup



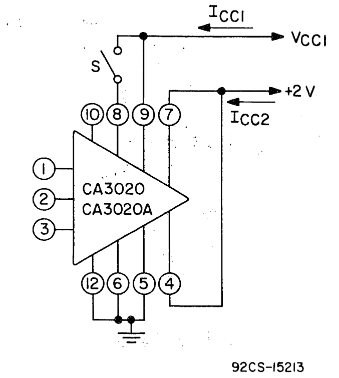
b. Differential Amplifier Characteristics



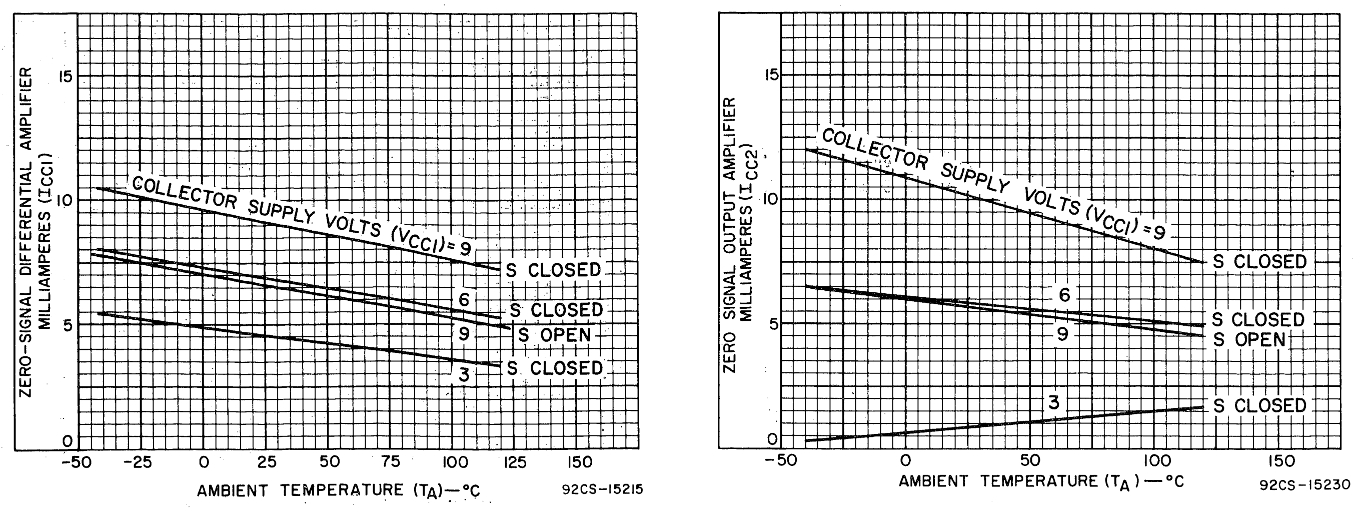
c. Output Amplifier Characteristics

Fig.6

ZERO SIGNAL AMPLIFIER CURRENT vs AMBIENT TEMPERATURE



a. Test Setup

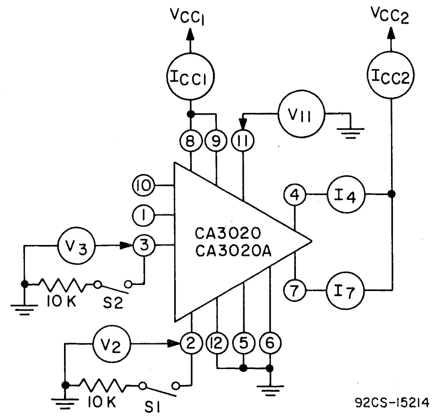


b. Differential Amplifier Characteristics

Fig.7

c. Output Amplifier Characteristics

STATIC CURRENT AND VOLTAGE TEST CIRCUIT



CURRENTS OR VOLTAGES	S1	S2
$I_{4\text{-IDLE}}$	open	open
$I_{7\text{-IDLE}}$	open	open
$I_{4\text{-PEAK}}$	open	close
$I_{7\text{-PEAK}}$	close	open
$I_{4\text{-CUTOFF}}$	close	open
$I_{7\text{-CUTOFF}}$	open	close

CURRENTS OR VOLTAGES	S1	S2
I_{CC1}	open	open
I_{CC2}	open	open
V_2	open	open
V_3	open	open
V_{11}	open	open

Fig.8

MEASUREMENT OF BANDWIDTH AT -3 dB POINTS

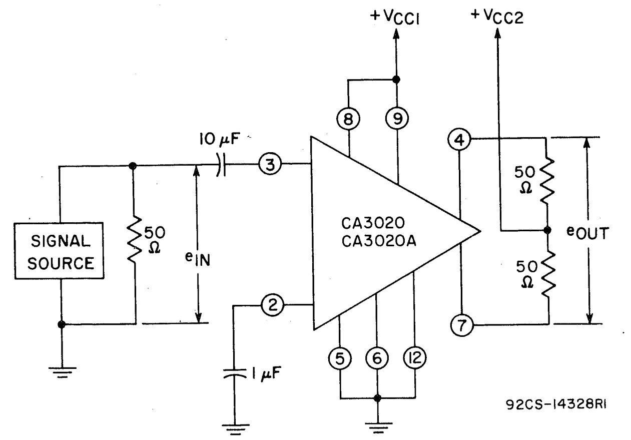
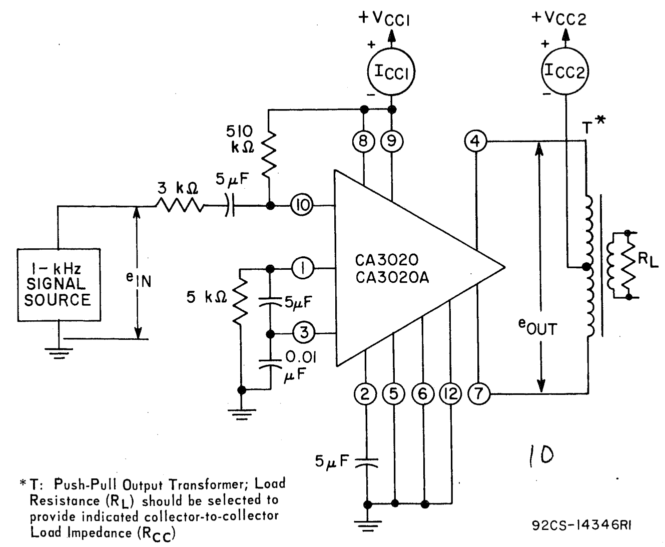


Fig.9

PROCEDURES:

1. Apply desired value of V_{CC_1} and V_{CC_2}
2. Apply 1 kHz input signal and adjust for e_{IN} = 5 mV (rms)
3. Record the resulting value of e_{OUT} in dB (reference value)
4. Vary input-signal frequency, keeping e_{IN} constant at 5 mV, and record frequencies above and below 1 kHz at which e_{OUT} decreases 3 dB below reference value.
5. Record bandwidth as frequency range between -3 dB points.

MEASUREMENTS OF ZERO-SIGNAL DC CURRENT DRAIN, MAXIMUM-SIGNAL DC CURRENT DRAIN, MAXIMUM POWER OUTPUT, CIRCUIT EFFICIENCY, SENSITIVITY, AND TRANSDUCER POWER GAIN



*T: Push-Pull Output Transformer; Load Resistance (R_L) should be selected to provide indicated collector-to-collector Load Impedance (R_{CC})

10

Fig.10

PROCEDURES:

Zero-Signal DC Current Drain

1. Apply desired Value of V_{CC_1} and V_{CC_2} and reduce e_{IN} to 0V
2. Record resulting values of I_{CC_1} and I_{CC_2} in mA as Zero-Signal DC Current Drain.

Maximum-Signal DC Current Drain, Maximum Power Output, Circuit Efficiency, Sensitivity, and Transducer Power Gain

1. Apply desired value of V_{CC_1} and V_{CC_2} and adjust e_{IN} to the value at which the Total Harmonic Distortion in the output of the amplifier = 10%
2. Record resulting value of I_{CC_1} and I_{CC_2} in mA as Maximum-Signal DC Current Drain
3. Determine resulting amplifier power output in watts and record as Maximum Power Output (P_{OUT})
4. Calculate Circuit Efficiency (η) in % as follows:

$$\eta = 100 \frac{P_{OUT}}{V_{CC_1} I_{CC_1} + V_{CC_2} I_{CC_2}}$$

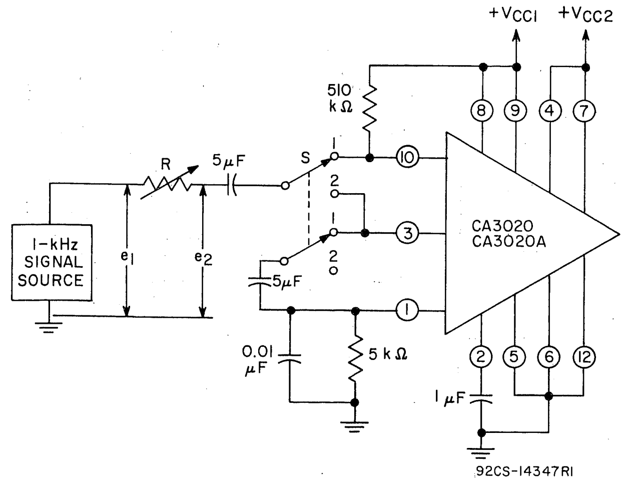
where P_{OUT} is in watts, V_{CC_1} and V_{CC_2} are in volts, and I_{CC_1} and I_{CC_2} are in amperes.

5. Record value of e_{IN} in mV (rms) required in Step 1 as Sensitivity (e_{IN})
6. Calculate Transducer Power Gain (G_p) in dB as follows:

$$G_p = 10 \log_{10} \frac{P_{OUT}}{P_{IN}}$$

where P_{IN} (in mW) $= \dfrac{e_{IN}^2}{3000 + R_{IN(10)}}$

MEASUREMENT OF INPUT RESISTANCE



PROCEDURES:

Input Resistance Terminal 10 to Ground ($R_{IN_{10}}$)

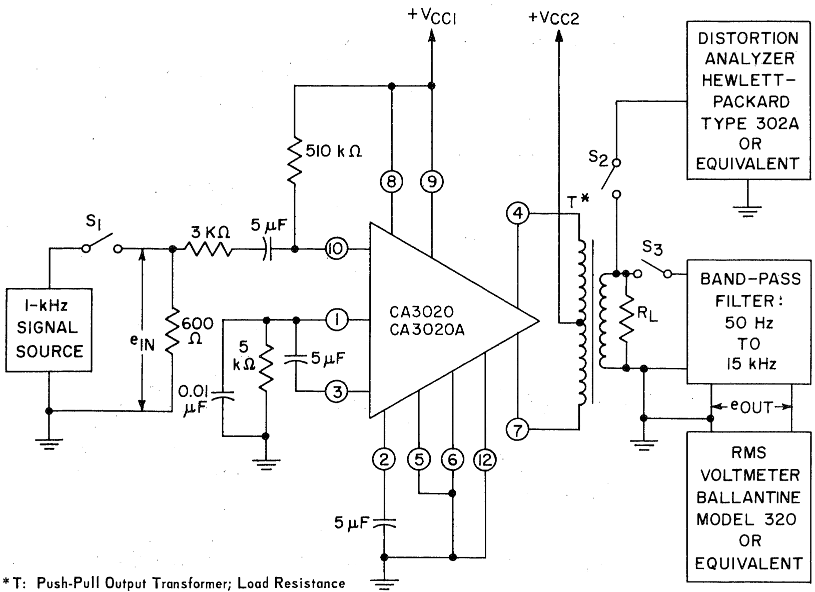
1. Apply desired value of V_{CC_1} and V_{CC_2} and set S in Position 1
2. Adjust 1-kHz input for desired signal level of measurement
3. Adjust R for $e_2 = e_1/2$
4. Record resulting value of R as $R_{IN_{10}}$

Input Resistance Terminal 3 to Ground (R_{IN_3})

1. Apply desired value of V_{CC_1} and V_{CC_2} set S in Position 2
2. Adjust 1-kHz input for desired signal level of measurement
3. Adjust R for $e_2 = e_1/2$
4. Record resulting value of R as R_{IN_3}

Fig.11

MEASUREMENT OF SIGNAL-TO-NOISE RATIO AND TOTAL HARMONIC DISTORTION


+VCC1
+VCC2
DISTORTION ANALYZER HEWLETT-PACKARD TYPE 302A OR EQUIVALENT
510 kΩ
S2
S1
3KΩ
5μF
T*
S3
1-kHz SIGNAL SOURCE
eIN
600 Ω
5 kΩ
5μF
0.01 μF
CA3020
CA3020A
RL
BAND-PASS FILTER: 50 Hz TO 15 kHz
eOUT
RMS VOLTMETER BALLANTINE MODEL 320 OR EQUIVALENT
5μF
8
9
4
10
1
3
7
2
5
6
12

*T: Push-Pull Output Transformer; Load Resistance (R_L) should be selected to provide indicated collector-to-collector Load Impedance (R_{CC})

92CM-14329RI

PROCEDURES:

Signal-to-Noise Ratio

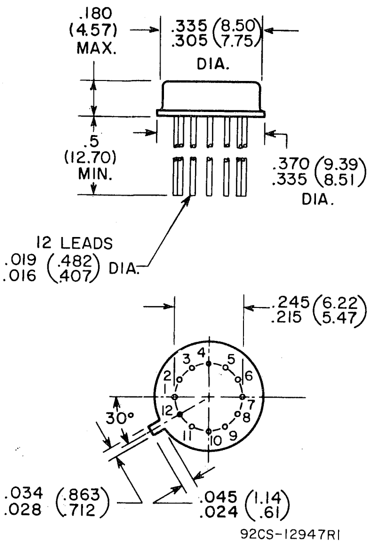
1. Close S_1 and S_3; open S_2
2. Apply desired values of V_{CC_1} and V_{CC_2}
3. Adjust e_{IN} for an amplifier output of 150mW and record resulting value of E_{OUT} in dB as $e_{OUT\,1}$ (reference value)
4. Open S_1 and record resulting value of e_{OUT} in dB as e_{OUT_2}
5. Signal-to-Noise Ratio (S/N) = $20\log_{10} \dfrac{e_{OUT_1}}{e_{OUT_2}}$.

Total Harmonic Distortion

1. Close S_1 and S_2; open S_3
2. Apply desired values of V_{CC_1} and V_{CC_2}
3. Adjust e_{IN} for desired level amplifier output power
4. Record Total Harmonic Distortion (THD) in %

Fig.12

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES AND MILLIMETERS

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.